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PR scientist continues lab legacy of technology advances

by Adrian DeNardo, Propulsion Directorate

WRIGHT-PATTERSON AIR FORCE BASE, Ohio —The Air Force Research Laboratory's Dr. William Copenhaver is continuing an AFRL legacy of turbine engine technology development that has significant influence on the advancement of these important propulsion systems. Copenhaver performs this fundamental research in the Compressor Aero Research Laboratory, known as the "CARL" by Propulsion Directorate (PR) personnel.

Working in the laboratory, Copenhaver combines talented people who work with unique equipment in a synergism to understand the science of the airflows of turbine engine compressors and fans. In the process, they have made fundamental discoveries about compressor airflow behavior. With that knowledge in hand, Copenhaver and his research team lead the way to new technology development for advanced turbine engines. These advanced engines are a continuing legacy – the legacy that has produced the best military turbine engines in the world.

The history of compressor research at Wright-Patterson Air Force Base stretches back to the early part of the 20th century, when scientists and engineers worked on turbosuperchargers for piston engines. The fundamental research that Copenhaver conducts at the CARL represents the state-of-the-art in jet engine compressor science.

His research concentrates on the various components of the jet engine front end – the fan and compressor rotors and stators – the primary air movers and controllers and their interaction with one another. This is particularly important as the gas turbine engine evolves to a higher-performing machine that is shorter, lighter, and more efficient and durable than anything before.

Becoming one of the nation's leaders in this particular scientific endeavour did not happen overnight for Copenhaver. After graduating with a master's degree from Virginia Tech and working in the chemical processing industry for two years, he accepted a position as test engineer at the PR's Compressor Research Facility in 1980.

After getting a solid grounding in compressor performance and testing techniques, he moved to the CARL to work with the renowned Dr. Art Wennerstrom. At that time, Wennerstrom had been working to understand and develop the science and technology of the swept fan, a fan design now coming into use in advanced turbine engines. Copenhaver continued to work with Wennerstrom until the latter's retirement in 1991. At that time, Copenhaver assumed management of the CARL, and maintained that position until 2000 when he assumed greater responsibilities in the Turbine Engine Division. In 1995, the research work on swept fans ended. Today, Copenhaver's main efforts are aimed at understanding blade row interactions and flow control in compressors.

This pioneering work by Copenhaver has demonstrated that not only do we need to be concerned with airflow in one direction, but also the impact on blade rows by the row behind it. According to Copenhaver, "We are within one to three years of a relatively full understanding of the phenomena and its affects on compressor performance. We will understand it well enough to model it."

The ability to model the phenomena results in the payoff – namely; the number of design iterations for a compressor can be drastically reduced, resulting in dramatic savings during development.

For flow control, he estimates that he is seven to 10 years away from understanding the physics of it at the same level as blade row interactions. Even so, his goal is to meet the 2010 technology insertion date requirement for these technologies.

Both efforts are aimed at making revolutionary advances to gas turbine engines, and to support the objectives within the Versatile Advanced Affordable Turbine Engine (VAATE) technology development

Continued on page 2

Continued from page 2

program. This national program has goals of improving the affordability of turbine engines by 10 times. Much of Copenhaver's work ties directly into those goals and are critical to VAATE's success.

Of course, revolutionary advances require a research focus on risky, but very high payoff technologies. Within the VAATE program is an organizational structure called the High Impact Technologies (HIT) Panel chaired by Copenhaver. This panel coordinates numerous technologies, which, if successfully developed, will help make the affordability goals for VAATE a reality. Two of these technologies, flow control and high stage loading, sit squarely in the research targets of the work Copenhaver is carrying on in the CARL.

One of the significant findings resulting from Copenhaver's work is the connection of blade row interactions with high cycle fatigue and overall compressor performance. High cycle fatigue is one of the leading causes of turbine engine failure, and has been under attack by the turbine engine community for a number of years. By understanding the overall blade row interactions, Copenhaver has been able to identify fluid mechanical drivers of potential failure modes of high performance compressors.

"I am most proud of my role as mentor," Copenhaver stated. He has mentored 11 doctorate and master's degree candidates, while developing the science and technology necessary for a robust military turbine engine program. By mentoring, Copenhaver hopes to keep a broad knowledge base across many disciplines that will further ensure that military needs are met.

To make sure that this knowledge base continues, it is necessary for Copenhaver to collaborate on his work. He currently has active partnerships with the Air Force Office of Scientific Research, Virginia Polytechnic and State University, the Dayton Area Graduate Studies Institute, major turbine engine manufacturers, and local support contractors. This is perhaps one of the most significant aspects of his work. Military requirements for turbine engines are often beyond commercial needs in performance, affordability and durability.

By involving both industry and academia in leading edge research and development, Copenhaver meets the military requirement to have the world's best turbine propulsion. Commercial enterprises benefit as well.

"If I was not doing research on turbine engine technology, I would be a carpenter," said Copenhaver when asked about his other interests. It's a good bet that gas turbine engine manufacturers are glad that Copenhaver does research on turbine engine technology as they search for the advanced technology needed to make the turbine engine the ever more efficient and durable machine that powers an ever increasing segment of our national infrastructure. **@**